

AMENDMENTS TO THE CLAIMS

1. (Currently amended) A battery charging system comprising:
a power supply that provides cyclic charging pulses to terminals of a battery, wherein the application of the charging pulses ~~has a current component and results in a voltage component~~ at the terminals that ~~varies between~~ includes a quiescent first voltage before the application of each pulse and a maximum second voltage during the application of each pulse;
a battery monitoring circuit ~~adapted to that~~ monitors the first voltage and the second voltage of one or more of battery's parameters that respond to the charging pulses at the terminals; and
a control module that adjusts the configuration of the ~~current component of the charging pulses so as to maintain the voltage component in a range between the quiescent first voltage and the maximum second voltage in response to the monitored battery parameter~~ in selected ranges with respect to desired values of the first and second voltages.
2. (Original) The battery charging system of Claim 1, wherein the charging pulse is a positive pulse.
3. (Currently amended) The battery charging system of Claim 2, wherein the ~~current component of the charging pulse~~ comprises a square shaped current pulse having a first amplitude and a first width and wherein the charging cycle has a first period.
4. (Original) The battery charging system of Claim 3, wherein the first amplitude has a range of approximately 0 to 20 Coulombs/second.
5. (Original) The battery charging system of Claim 3, wherein the first width has a range of approximately 50 to 1000 milliseconds.
6. (Original) The battery charging system of Claim 3, wherein the first period has a range of approximately 100 to 2000 milliseconds.

7. (Currently amended) The battery charging system of Claim 2 ~~3~~, wherein ~~the a~~ voltage component representation of the charging pulse depends on the ~~current component~~ associated with the charging pulse and resistance of the battery.

8. (Currently amended) The battery charging system of Claim 7, ~~wherein the battery monitoring circuit monitors the quiescent voltage and the maximum voltage~~ wherein the first voltage is a quiescent voltage of the battery at the terminals and the second voltage is the maximum voltage at the terminal during a given charging pulse, such that a charging voltage is defined as the difference between the maximum voltage and the quiescent voltage and wherein the charging voltage is indicative of the battery's ability to absorb charge.

9. (Currently amended) The battery charging system of Claim 8, wherein the control module maintains the charging voltage at a selected voltage level by adjusting ~~the configuration of the current component of~~ associated with the charging pulses.

10. (Original) The battery charging system of Claim 9, wherein the selected voltage level is approximately 1 volt.

11. (Currently amended) The battery charging system of Claim 9, wherein maintaining the charging voltage at the selected voltage level comprises maintaining the existing ~~configuration~~ value of the ~~current component~~ if the monitored charging voltage is approximately equal to the selected voltage level.

12. (Original) The battery charging system of Claim 9, wherein maintaining the charging voltage at the selected voltage level comprises increasing the first amplitude of the current pulse by a selected amount if the monitored charging voltage is less than the selected voltage level.

13. (Original) The battery charging system of Claim 12, wherein the selected amount of current pulse increase is approximately 0.05 Coulomb/second.

14. (Original) The battery charging system of Claim 9, wherein maintaining the charging voltage at the selected voltage level comprises decreasing the first amplitude of the current pulse by a selected amount if the monitored charging voltage is greater than the selected voltage level.

15. (Original) The battery charging system of Claim 14, wherein the selected amount of current pulse decrease is approximately 0.05 Coulomb/second.

16. (Currently amended) The battery charging system of Claim 4 ~~3~~, wherein the control module ~~further~~ maintains the quiescent voltage at a the selected quiescent voltage level range by adjusting ~~the configuration of the current component of~~ associated with the charging pulses wherein the quiescent voltage provides some indication of charge state of the battery.

17. (Original) The battery charging system of Claim 16, wherein the battery is a 12 volt sealed lead acid battery.

18. (Currently amended) The battery charging system of Claim 17, wherein the ~~selected~~ desired quiescent voltage level is approximately 13.5 volts.

19. (Currently amended) The battery charging system of Claim 16, wherein maintaining the quiescent voltage at the ~~selected~~ desired quiescent voltage level comprises maintaining the existing configuration of the current component if the monitored quiescent voltage is approximately equal to the ~~selected~~ desired quiescent voltage level.

20. (Currently amended) The battery charging system of Claim 16, wherein maintaining the quiescent voltage at the ~~selected~~ desired quiescent voltage level comprises increasing the first width of the current pulse by a selected amount if the monitored quiescent voltage is less than the selected quiescent voltage level.

21. (Original) The battery charging system of Claim 20, wherein the selected amount of current pulse width increase is approximately 10 milliseconds.

22. (Original) The battery charging system of Claim 16, wherein maintaining the quiescent voltage at the selected quiescent voltage level comprises decreasing the first width of the current pulse by a selected amount if the monitored quiescent voltage is greater than the selected quiescent voltage level.

23. (Original) The battery charging system of Claim 22, wherein the selected amount of current pulse width decrease is approximately 10 milliseconds.

24. (Currently amended) The battery charging system of Claim 1, wherein the ~~current component of the~~ charging pulse comprises a positive square charging current pulse followed by a negative square discharging pulse having a discharging pulse amplitude and a discharging pulse width wherein the discharging pulse aids the battery in charge absorption.

25. (Original) The battery charging system of Claim 24, wherein the discharging pulse amplitude has a range of approximately 20 to 200 Coulombs/second.

26. (Original) The battery charging system of Claim 24, wherein the discharging pulse width has a range of approximately 1 to 20 milliseconds.

27. (Currently amended) The battery charging system of Claim 24, wherein the battery monitoring circuit further monitors the ~~quiescent~~ first voltage and a voltage immediately following the discharging pulse wherein a post-discharge voltage is defined as the difference between the voltage immediately following the discharging pulse and the ~~quiescent~~ first voltage and wherein the post-discharge voltage is indicative of the effectiveness of the discharge process.

28. (Original) The battery charging system of Claim 27, wherein the control module maintains the post-discharge voltage at a selected post-discharge voltage level by adjusting the configuration of the current component of the charging pulses.

29. (Original) The battery charging system of Claim 28, wherein the selected post-discharge voltage level is approximately 0.2 volt.

30. (Currently amended) The battery charging system of Claim 28, wherein maintaining the post-discharge voltage at the selected post-discharge voltage level comprises maintaining the existing configuration of the ~~current component~~ discharging pulse if the monitored post-discharge voltage is approximately equal to the selected post-discharge voltage level.

31. (Original) The battery charging system of Claim 28, wherein maintaining the post-discharge voltage at the selected post-discharge voltage level comprises decreasing the discharging pulse amplitude by a selected amount if the monitored post-discharge voltage is less than the selected post-discharge voltage level.

32. (Original) The battery charging system of Claim 31, wherein the selected amount of discharging pulse amplitude decrease is approximately 0.05 Coulomb/second.

33. (Original) The battery charging system of Claim 28, wherein maintaining the post-discharge voltage at the selected post-discharge voltage level comprises increasing the discharging pulse amplitude by a selected amount if the monitored post-discharge voltage is greater than the selected post-discharge voltage level.

34. (Original) The battery charging system of Claim 33, wherein the selected amount of discharging pulse amplitude increase is approximately 0.05 Coulomb/second.

35. (Original) The battery charging system of Claim 1, wherein the control module further monitors a duty cycle of the pulse charging cycle to determine state of charge of the battery wherein the duty cycle comprises a ratio of charging pulse width to the charging cycle period.

36. (Currently amended) The battery charging system of Claim 35, wherein the duty cycle is monitored while maintaining the quiescent first voltage at a specified the desired level.

37. (Currently amended) A method of pulse charging a battery, the method comprising:

applying cycles of charging current pulses to the battery;

monitoring a first voltage and a second voltage of the battery in response to the charging current pulses, wherein the first voltage is the voltage of the battery before the application of each charging current pulse and the second voltage is the voltage of the battery during the application of each charging current pulse ~~voltage of the battery during selected points of each charging cycle wherein the voltage ranges from a quiescent voltage to a maximum voltage; and~~

adjusting the configuration of the current pulse so as to maintain the first voltage and the second voltage in a selected ranges with respect to their respective desired values ~~between the quiescent voltage and the maximum voltage in response to the monitored voltage.~~

38. (Original) The method of Claim 37, wherein applying cycles of charging current pulse comprises applying cycles of positive square current pulse having a first amplitude and a first width and wherein the charging cycle has a first period.

39. (Original) The method of Claim 38, wherein the first amplitude has a range of approximately 0 to 20 Coulombs/second.

40. (Original) The method of Claim 38, wherein the first width has a range of approximately 50 to 1000 milliseconds.

41. (Original) The method of Claim 38, wherein the first period has a range of approximately 100 to 2000 milliseconds.

42. (Currently amended) The method of Claim 37, wherein the first voltage is a quiescent voltage of the battery and the second voltage is the maximum voltage of the battery

during a given charging pulse, such that ~~monitoring voltage of the battery comprises monitoring the quiescent voltage and the maximum voltage wherein~~ a charging voltage is defined as the difference between the maximum voltage and the quiescent voltage is monitored.

43. (Original) The method of Claim 42, wherein maintaining the voltage comprises maintaining the charging voltage at a selected voltage level.

44. (Original) The method of Claim 43, wherein the selected voltage level is approximately 1 volt.

45. (Currently amended) The method of Claim 42, wherein maintaining the voltage comprises maintaining the quiescent voltage at ~~a selected~~ the desired quiescent voltage level.

46. (Currently amended) The method of Claim 45, wherein the ~~selected~~ desired quiescent voltage level is approximately 13.5 volts for a 12 volt battery.

47. (Original) The method of Claim 37, wherein adjusting the configuration of the current pulse comprises increasing the first amplitude of the current pulse if the monitored charging voltage is less than the selected voltage level.

48. (Original) The method of Claim 47, wherein the first amplitude is increased by approximately 0.05 Coulomb/second.

49. (Original) The method of Claim 37, wherein adjusting the configuration of the current pulse comprises decreasing the first amplitude of the current pulse if the monitored charging voltage is greater than the selected voltage level.

50. (Original) The method of Claim 49, wherein the first amplitude is decreased by approximately 0.05 Coulomb/second.

51. (Currently amended) The method of Claim 37, wherein adjusting the configuration of the current pulse comprises increasing the first width of the current pulse if the monitored ~~quiescent~~ first voltage is less than the ~~selected~~ desired ~~quiescent~~ first voltage level.

52. (Original) The method of Claim 51, wherein the first width is increased by approximately 10 milliseconds.

53. (Currently amended) The method of Claim 37, wherein adjusting the configuration of the current pulse comprises decreasing the first width of the current pulse if the monitored ~~quiescent~~ first voltage is greater than the ~~selected~~ desired ~~quiescent~~ first voltage level.

54. (Original) The method of Claim 53, wherein the first width is decreased by approximately 10 milliseconds.

55. (Original) The method of Claim 37, wherein applying cycles of charging current pulse comprises applying cycles of a positive square charging pulse followed by a negative square discharging pulse wherein the discharging pulse has a discharging pulse amplitude and a discharging pulse width.

56. (Original) The method of Claim 55, wherein the discharging pulse amplitude has a range of approximately 20 to 200 Coulombs/second.

57. (Original) The method of Claim 55, wherein the discharging pulse width has a range of approximately 1 to 20 milliseconds.

58. (Currently amended) The method of Claim 55, wherein monitoring voltage of the battery comprises monitoring the ~~quiescent~~ first voltage and a voltage immediately following the discharging pulse wherein a post-discharge voltage is defined as the difference between the voltage immediately following the discharging pulse and the ~~quiescent~~ first voltage.

59. (Original) The method of Claim 58, wherein maintaining the voltage comprises maintaining the post-discharge voltage at a selected post-discharge voltage level.

60. (Original) The method of Claim 59, wherein the selected post-discharge voltage level is approximately 0.2 volt.

61. (Original) The method of Claim 55, wherein adjusting the configuration of the current pulse comprises decreasing the discharging pulse amplitude if the monitored post-discharge voltage is less than the selected post-discharge voltage level.

62. (Original) The method of Claim 61, wherein the discharging pulse amplitude is decreased by approximately 0.05 Coulomb/second.

63. (Original) The method of Claim 55, wherein adjusting the configuration of the current pulse comprises increasing the discharging pulse amplitude if the monitored post-discharge voltage is greater than the selected post-discharge voltage level.

64. (Original) The method of Claim 63, wherein the discharging pulse amplitude is increased by approximately 0.05 Coulomb/second.

Appl. No. : 10/099,932
Filed : March 13, 2002

65. (Original) The method of Claim 37, wherein adjusting the configuration of the current pulse results in change in duty cycle of the charging pulse wherein the duty cycle comprises a ratio between the width of the charging pulse to the period of the cycle.

66. (Currently amended) The method of Claim 65, wherein the duty cycle is monitored wherein the duty cycle is a good indicator of state of charge for ~~a wide variety~~ different types of batteries and wherein the duty cycle is generally independent of the type of battery.